Course ID: ECE 341 Communication Systems- Fall
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235D/ Office Hours: Mondays and Wednesdays 11:00am - 12:00pm
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Homework #4
Corresponding to Chapter 4 of Principles of Communications, Rodger E. Zimmer and William H. Tranter, John Wiley, 7th Edition.

1.   Given that $J_0(5)$=-0.178, $J_1(5)$=-0.328, find $J_3(5)$ and $J_4(5)$.

2.   A transmitter uses a carrier frequency of 1000Hz and the unmodulated carrier is $A_c\cos(2\pi f_c t)$. Determine the phase and the frequency deviation for the following transmitter outputs: a) $x_c(t)=\cos[2\pi 1000t+40\sin(5t^2)]$ and b) $x_c(t)=\cos[2\pi 1200t^2]$.

3.   An FM modulator has output $x_c\left(t\right)=100cos[2\pi f_c t+2\pi f_d \int\limits^{t} m(\text{a})\,d\text{a}]$, where f_d=20Hz/V

and m(t)=4Π[(1/8)*(t-4)]: a) Determine the phase deviation in radians and the frequency deviation in Hz, b) determine the peak frequency deviation in Hz, c) determine the peak phase deviation in radians, and d) determine the power at the modulator output.

To be delivered at instructor's office: 11 Nov. 2019

Good Luck!

1. Given that $J_0(5) = -0.178$, $J_1(5) = -0.328$, find $J_3(5)$ and $J_4(5)$.

$$J_0(5) = J_{n-1}(\beta) = -0.178$$

$$J_1(5) = J_n(\beta) = -0.328 \qquad\qquad \beta = 5$$

$$J_2(5) = J_{n+1}(\beta) \rightarrow n = 1$$

$$= \frac{2(1)}{5}(-0.328) - (-0.178) = 0.0468$$

$$J_3(5) = J_{2+1}(\beta) \rightarrow n = 2$$

$$= \frac{2(2)}{5} J_2(5) - J_{2-1}(5)$$

$$= \frac{2(2)}{5}(0.0468) - (-0.328) = \boxed{0.36544}$$

$$J_4(5) = J_{3+1}(\beta) \rightarrow n = 3$$

$$= \frac{2(3)}{5} J_3(5) - J_{3-1}(5)$$

$$= \frac{6}{5}(0.36544) - (0.0468) = \boxed{0.391728}$$

2. A transmitter uses a carrier frequency of 1000Hz and the unmodulated carrier is $A_c \cos(2\pi f_c t)$. Determine the phase and the frequency deviation for the following transmitter outputs:

a) $x_c(t) = \cos[2\pi 1000 t + 40\sin(5t^2)]$

$$f_c = 1000 \text{Hz} \quad \longrightarrow \quad A_c \cos\left(2\pi \, 1000t\right)$$

$$\phi(t) = 40\sin(5t^2)$$

$$\frac{d\phi}{dt} = 400t \cos\left(5t^2\right)$$

b) $x_c(t) = \cos[2\pi 1200 t^2]$

$$A_c \cos\left(2\pi \, 1000t\right)$$

$$2\pi 1000t + \phi(t) = 2\pi \, 1200t^2$$

$$\phi(t) = 2\pi\left(1200t^2 - 1000t\right) = 2400\pi t^2 - 2000\pi t$$

$$\frac{d\phi}{dt} = 2\pi\left(2400t - 1000\right) = 4800\pi t - 2000\pi$$

3. An FM modulator has output $x_c(t) = 100\cos\left[2\pi f_c t + 2\pi f_d \int^t m(\alpha)d\alpha\right]$, where $f_d = 20$Hz/V and $m(t) = 4\Pi\left[\frac{1}{8}(t-4)\right]$

a) Determine the phase deviation in radians and the frequency deviation in Hz

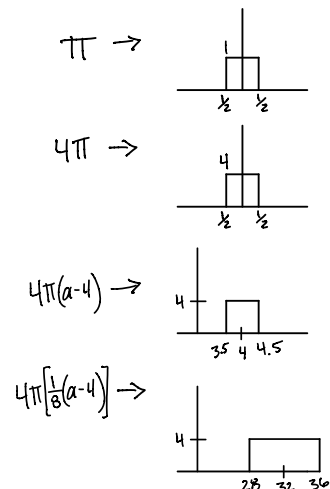$$\phi(t) = 2\pi(20)\int^t 4\pi\left[\frac{1}{8}(\alpha-4)\right]d\alpha$$

$$= 40\pi\int^t 4\,d\alpha$$

$$= 40\pi(4t)$$

$$= 160\pi t \text{ rad}$$

$$\frac{d\phi}{dt} = 160\pi\left(\frac{1}{2\pi}\right)$$

$$= 80 \text{ Hz}$$

b) Determine the peak frequency deviation in Hz

$$\frac{d\phi}{dt} = 80\text{Hz}$$

c) Determine the peak phase deviation in radians

$$\phi(t) = 2\pi(20)\int^t 4\pi\left[\frac{1}{8}(\alpha-4)\right]d\alpha$$

$$= 40\pi\int_{28}^{36} 4\,d\alpha$$

$$= 160\pi t \Big|_{28}^{36}$$

$$= 1280\pi \text{ rad}$$

$\pi \rightarrow$

$4\pi \rightarrow$

$4\pi(\alpha-4) \rightarrow$

$4\pi\left[\frac{1}{8}(\alpha-4)\right] \rightarrow$

d) Determine the power at the modulator output

$$\langle x_c^2\rangle = \frac{A_c^2}{2} = \frac{(100)^2}{2} = 5000\text{W}$$